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Consideration on Drift and Translocation of Todarodes Pacificus larvae along the Pacific Coast of Japan

Takashi OKUTANI

As part of the special 1967-1969 "study on stock variations mechanisms aimed at greater precision in Todarodes Pacificus* fishing forecasts", the Tokai Fisheries Research Center was entrusted with part of the "Investigation of the TP regeneration mechanism and of the primary variations factors". This fisheries research center focused on two topics viz. (1) the morphological study of TP larvae and juveniles, and (2) the ecological study of the distribution, drift and translocation of the same.

Besides the survey data obtained during the period of the special study, we researched also other unprocessed data preserved from an earlier time. The present report is an overall compendium of the study results obtained regarding the above topics.

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*Translator's note: Sagittated calamary; Japanese common squid; abbreviated hereafter as TP.

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1) Outline of the survey performed during the period

(1) Study of samples gathered through surface horizontal towing, through oblique towing with chi* A nets during various survey cruises by the Shigetaka-maru ship along the Pacific coast and offshore (16 trips from April 1967 to March 1970; 1153 sites) and of samples gathered with chi A nets along the fishing boundaries set for the various prefectures under the Tokai regional administration (partially published in the report of the Tokai Fisheries Research Center).

(2) Survey of the various samples gathered by the Shigetakamaru ship prior to this special study and preserved at the Tokai Region Fisheries Center (results partially published in the report from the Fisheries Research Center).

(3) Survey of the arrivals of larval squids captured in stationary nets along the various places along the Pacific Ocean (southern Wakayama prefecture, Sagami Bay, Sanriku coast and so on), in nets towed from ships and from land, and in the spoon nets of research vessels.

(4) Gathering of data about the spawning grounds in the various places along the Pacific coast (southern Kyushu, Wakayama prefecture, Sagami Bay and so on), about the state of generation and incoming migrations of larval squids.

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*Translator's note: Symbol unclear, small-mesh net? Larval net? Same hereafter.

2) Results obtained and discussion

(1) Morphological study of the larvae and juveniles

We observed and studied the development of TP larvae and juveniles during the rhynchoteuthion period and the later growth, basing ourselves on the work of Hamabe (1960, 1962), Okutani (1965) and Okiyama (1965), and performed also a taxonomic and morphological study of the other decapod larvae and juveniles (Okutani 1968, 1969).

We were first anticipating that other species of the same family might be admixed to the TP larvae and juveniles gathered by surface horizontal towing of chi A nets on the Pacific side. Among the 2,002 samples of surface squid larvae and juveniles collected by the Shigetaka-maru from 1960 to 1965, 799 belonged to the Ommastrephes family and among these, 789 specimens were from the viewpoint of continuity characteristics of morphological changes identified as TP. It was also made evident that a little less than 40% of the surface squid larvae and juveniles are TP. As a result of numerous studies about naturally produced larvae and juveniles, the reporting researchers came to think that the morphological differences are not only due to differences found within wide environments such as the Japan Sea and the Pacific Ocean, but also to atrophy at particular times and to variations in the expansion or contraction of the chromatophores. They also were of the opinion that the other species of the same family could be distinguished through the relative length of the fused proboscis-form tentacles at the rhynchoteuthion period, by the mantle length, chromatophore density, mantle membrane morphology and contraction degree, size of the scales and the like at the various times of the fused-tentacles

separation stage. As an example, the mantle dorsal length at the final rhynchoteuthion period is 11.5 mm for TP from the Pacific (Okutani, 1968) and 15.5 mm for TP from the Sea of Japan (Hamabe 1962). In the Ryukyu squid group the fused proboscis-form tentacles separate already at 10 mm.

(2) Study of distribution, drift

(i) Distribution of the larvae and juveniles in the sea (survey done by research ship)

Among the trips conducted with the Shigetakamaru, the spawning survey performed every year in January-March was continued throughout 1967-1969, and meticulous collections were carried out from the eastern coast of Kyushu to the open sea off Kagoshima. As a result, one noted differences in the amounts collected depending on the year (distribution density). There is not much difference between the sites and sizes reported by Hamabe (1962; distribution type based on 0-150 m vertical gathering, mainly with medium A' nets, 1959-1962 portion) and Okutani (1968, 0 m surface distribution-type based on chi A nets). It was found in the surveys of 1967, 1968 that more young larvae close to the development period were gathered as one moved west, and that the appearance of the larvae and juveniles took place on the axis of the Kuroshio current and where branches of the same current faced the coast, and that there tended to be a good correspondence between the coasts abandoned or approached by the Kuroshio on the one hand and the appearance places of larvae and juveniles on the other (because of the rebuilding of the Shigetaka-maru in 1969, there was a lack of investigation in 1969). p. 45

We also examined the squid larvae and juveniles contained among the samples collected with chi net oblique towing for a mackerel (masaba; Pneumatophorus japonicus: Tr.) feed biological survey carried out along the Pacific coast of Eastern Honshu from the open sea off Sagami to Sanriku (Okutani, 1969). The samples used were mainly obtained from 65 dragnet hauls during 7 trips in the winter (Nov-Jan of 1965-1968). In 7 net loads were found 1.1 young rhynchoteuthion period TP larvae at the growth stage. Regarding the vertical distribution of TP larvae, Hamabe (1965) gathered specimens by different depths in a 0-100 m range (using a medium A net, and a Laevitt-type closing and opening device; the depths were 25, 50, 100 m). The larvae and juveniles were reported to be most numerous day and night in the 25 m and 50 m strata. Among the specimens gathered, there were TP rhynchoteuthion period larvae which had been caught by dragnets at a 200 m depth or higher. At the 200 m stratum, rhynchoteuthion period larvae of species other than TP appeared in the locked nets but there were no TP. p. 46

We note with special interest that the young rhynchoteuthions at the development period which in the earlier regular specimen collections apeared only extremely rarely on the Tokai coast were confirmed to be distributed during the winter at Tokiwa or also more to the north. It is also suggested that besides the main group forming during the winter-spring seasons (high density in zones of 20°C or more) in the waters southwest of Kyushu, there is also a small group forming off the Tokai coast. This seems to corroborate the view by Kawasaki (1968) about the possible presence of a local group centered on the Tokai area, view based on Niiya (1962), Yasui et al (1958) and the Tohoku Fisheries Research Center (1959).

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Even in April-May there is no change of tendency with regard to the volume of supply and mantle length composition among the larvae and juveniles obtained from the west in the Tokai coastal sea. We see some tendency of aggregation in the warm water masses of the Kuroshio (Okutani 1968).

As for the movements of later larvae and juveniles, we examined the surface samples caught with chi A nets over the entire range of the waters off Sanriku at the time of a survey of offshore mackerel schools, which survey was conducted mainly in June of 1967 and 1968. As this period is rather excessively late for a survey of TP larvae and juveniles distribution, we found only 8 individuals (mantle length: 9-15 mm) in 5 places when hauling 103 times a dragnet in 1967, and only 3 individuals (mantle length: 6-9 mm) in 3 places by hauling 96 times a dragnet in 1968. However, during both years the larvae and juveniles p. 47
tended to appear in the coastal waters in the warm water masses of the Kuroshio (in 1967, about 70-90 nautical miles and in 1968, about 60 nautical miles to the east of Mt. Kinka), and offshore at the front line of the 2nd branch of the Oyashio (in 1967 about 170 nautical miles east of Kamaishi, and in 1968, about 170 miles east of Funawatari). It was also ascertained that some individuals drifted along the mixed-waters band to the east. In the 1968 collection, one separate individual (mantle length: 8 mm) was captured at a point about 50 nautical miles southeast of Erimosaki. If one considers the water temperature, surface current distribution at the time (fast report from the Shigetakamaru), the specimen seems to have drifted along by crossing the front line of the Oyashio located fairly off to the north.

(ii) Distribution of squid larvae along the coasts (survey based mainly on fisheries catches)

In the past it was believed that the main spawning ground of TP was around the continental shelf in the Eastern China Sea. However through this special study the precise position was clarified on the basis of research done at the Western Fisheries and Southwest Fisheries Research Centers (present report).

Yet at this time, the apportionment volume and mechanism of the larvae and juveniles supplied from the same region to the Pacific side (Kuroshio) and to the Sea-of-Japan side (Tsushima warm current) is still unclear.

In January 1968 and January 1969 we inquired mainly among the operators on the Satsuma-Osumi peninsula coast (Kasasa, Nomaike, Akime, Kushi, Bo-Tomari, Makurasaki, Otomari, Uchinoura and others) about the spawning ecology of TP along the same coast, and obtained the following information.

(a) Incubating parents appear along the Satsuma peninsula in November-March and the larvae in December-May.

(b) It was witnessed that around March-May jellylike masses drifted in the sea at a depth of about 25 m off Tategami in the Kagoshima prefecture.

(c) A "gathering" ("yori") phenomenon was sometimes observed at Kuchierabushima Nanatsugama and on the eastern coast of Tanegashima (between Hamadahana and Osaki).

This information (even if somewhat inexact) suggests that one extremity of the spawning grounds provided on the Pacific side might be located around this area.

Many larval TP carried from their spawning grounds in the west by currents are pushed from the inner edge of the Kuroshio toward the coast by the separate branches facing the coast. We discovered this from the state of appearance of TP squid larvae and juveniles caught in the stationary nets, dragnets pulled by ships and from the land in the various places along the Pacific coast of Honshu such as the southern Wakayama prefecture, the inside of the Sagami Bay, the vicinity of Kamaishi in the Iwate prefecture. As a result, we see the appearance of squid larvae with a mantle of 50 mm or less mainly from November to May in the Honshu coastal waters. The smallest individuals entering the stationary nets have a mantle about 12 mm long. They are most numerous during December-March along the Kii Peninsula, during January-May in the Sagami Bay, during April-June along the Sanriku coast (Miyako-Kesennuma). Similar squid larvae (mantle length: 40-50 mm) are similarly collected in April off Choshi (Fishing state St. 05)where the Kuroshio flows eastward.

According to the surveys conducted by research ship, the TP p. 48
larvae and juveniles are distributed through relatively high-temperature areas immediately after flotation. One sees that when the mantle reaches about 20 mm in length, the squids adapt and become distributed in areas around 10° (Okutani 1968). Consequently, squid larvae having reached such level of development may sojourn in relatively cooler places along the coast. If we consider the larvae and juveniles captured at Shirasu in the southern Wakayama prefecture, we see the entry through the effect of the Kuroshio, of a group having 15-30 mm long mantles at the time when the temperature of the coastal water was 14°C or higher. After about one month of stay during which the mantles

grew to about 50 mm, the squids seemed to go away (with the increased swimming strength, they started a migration and disappeared, although some stayed).

Elsewhere, as explained above, the delivery of stocks to the Pacific coast is not a single phenomenon in the west only (that is, the southwest region of the China Sea - southern Kyushu) but it was suggested that there is a one-generation group sustaining the local group whose migration area is north of the Tokai region. However, the behaviour of the larval squids of this group is not completely known.

Nevertheless, as it is reported that the appearance of the larval squids along the Sanriku coast precedes the so-called summer squid fishing (mantle lenth: 13-20 cm), these larvae might have been replenished with larval squids of the main group originating from the west and do not so much appear to be supplied from the Sea-of-Japan side.

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3) Conclusion

The distribution and drift of TP larvae along the Pacific coast of Japan which we have discussed above may on the basis of various surveys conducted in the course of the special study pursued in 1967-1969 and of additional data be generally described as follows.

1. Individuals originating from small-scale spawnings grounds scattered south of Satsuma were added to the individuals supplied from the main spawning grounds in the Eastern China Sea, and these became the main group. There seems also to be small separate formation groups sustaining the Tokai-area local group.

2. The supply of squid larvae from the main formation in the west to the Tokai-area coast continues from the winter to May. As the waters of the Kuroshio come close to the coast, the larvae and juveniles are supplied to every coastal region in several separate waves. For a period of time the larvae stay and grow.

3. In the offshore waters south of Honshu, the larvae and juveniles are distributed only when the flow axis of the Kuroshio turns around the south. In the offshore waters east of Honshu, those larvae which were not able to become attached to the Sanriku coast, enter the mixed-waters zone together with the warm water masses, and drift eastward on the surface while being taken back into the waters of the Oyashio.

These facts show a drift distribution system which would also be practically normal for other fish larvae or juveniles or other plantkton organisms. The meaningful point is that the fact was actually confirmed during this period of study. Whether the above eastward drifting group becomes later an offshore replenishment group is an extremly important and interesting problem left to study.

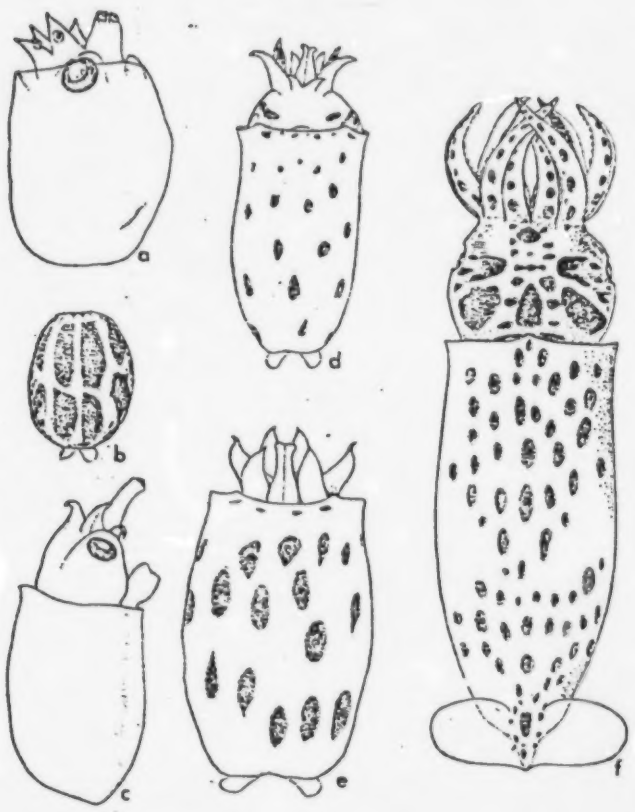

Fig. 1-31 Naturally-produced TP larvae and juveniles (a: larvae believed to be at the stage following immediately flotation; b: sample with degenerated head and legs; c-e: somewhat advanced rhynchoteuthion period; f: larvae after the rhynchoteuthion period; right-side scale: 1 mm

p. 45

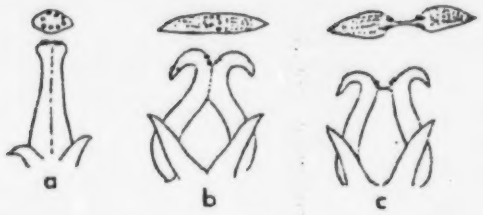

Fig. 1-32 Stage of fused-tentacle separation in rhynchoteuthion larvae

a. mantle length: 6 mm
b. same 9 mm
c. same 11.5 mm

All specimens collected with a chi A net from the Shigetaka maru

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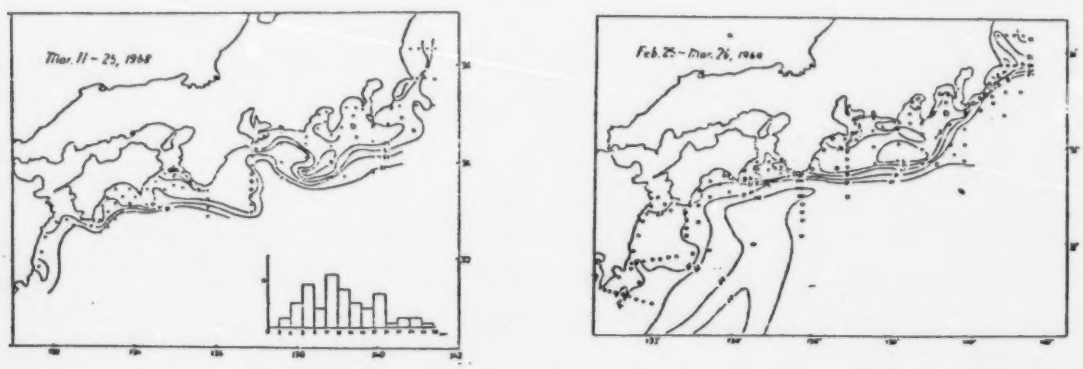

Fig. 1-33 Results of the spawning grounds surveys conducted in 1967 and 1968 by the Shigetaka maru; TP appearance sites based on chi A nets (black circles) and surface water temperature distribution p. 46

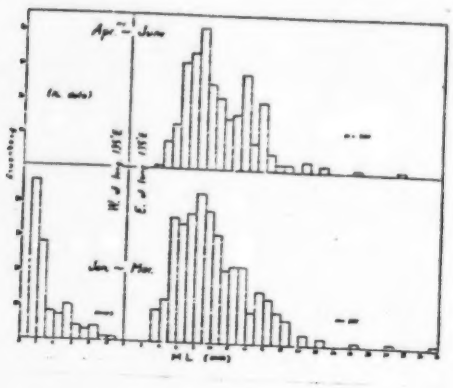

Fig. 1-34 Comparison of the mantle length composition of TP at the east longitude 135° eastwest line; samples collected with chi A in 1960-1965 by the Shigetaka maru

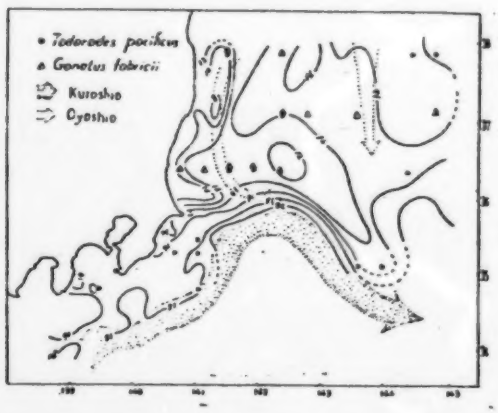

Fig. 1-35 Example of TP larvae distribution near the front line of the Kuroshio

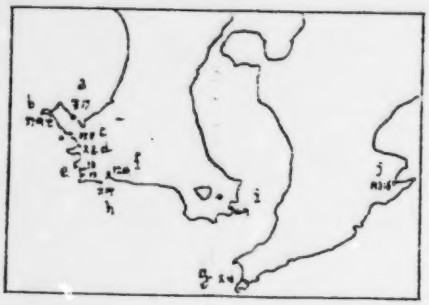

Fig. 1-36 Location of the Satsuma and Osumi regions where we conducted question surveys about TP in January 1968 and January 1969 p. 47

a Kasasa, b Nomaike, c Akime, d Kushi, e Bo-Tomari, f Makurasaki, g Otomari, h Tategami, i Yamakawa, j Uchinoura

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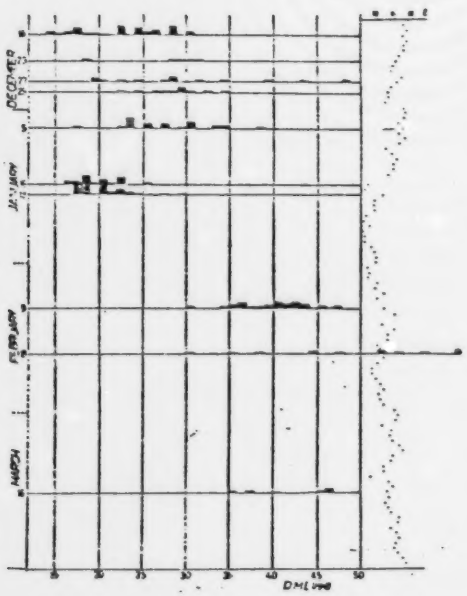

Fig. 1-37 Changes in the mantle length compositions of larval TP caught together with young sardines south of the Wakayama prefecture from December 1967 to March 1968; on the right stationary waters temperature in Tanabe

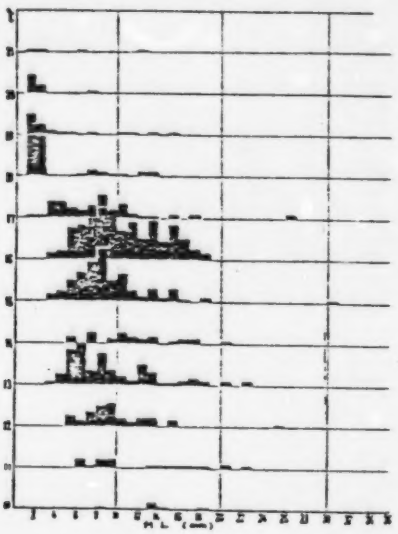

Fig. 1-38 Mantle length composition of TP larvae and juveniles as they appear by separate surface water temperatures; all samples gathered with chi A in 1960-1965 by the Shigetaka maru p. 48

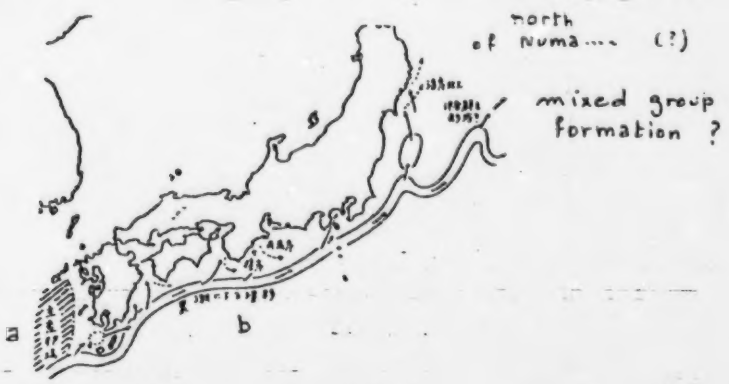

Fig. 1-39 Scheme of the distribution and drift of TP larvae along the Pacific coast

a. main spawning ground
b. translocation caused by the Kuroshio current

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